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METCM-based Messages from Climatological Data

by James L. Cogan and Patrick A. Haines

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Computational and Information Sciences Directorate, ARL

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14. ABSTRACT
Planning at test ranges may require a means to check on the potential range of projectiles given likely meteorological conditions. One means for planning purposes is to use climatological data to provide climate-based meteorological messages that serve as input to simulated firings. Consequently, we developed computer programs to convert climatological data supplied by the 14th Weather Squadron of the U.S. Air Force (AF) into a form that contains data similar to what are found in the Computer Meteorological Message (METCM). The METCM is a commonly used form of meteorological information for artillery applications. The AF can generate mean values and standard deviations of height, temperature, wind speed and direction, and various moisture variables such as relative humidity and dew point, plus other meteorological variables from archived climatological data. Based on potential needs, we provided output that included the message computed using the climatological means and messages that added or subtracted one or more standard deviations from one or more of the meteorological variables.

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1. Introduction

Planning at test ranges that includes artillery and related systems may require a means to check on the potential range of projectiles given likely meteorological conditions. One means for planning purposes is to use climatological data to provide climate-based meteorological messages that serve as input to simulated firings. Consequently, we developed computer programs to convert climatological data supplied by the 14th Weather Squadron of the U.S. Air Force (AF) into a form that contains data similar to what are found in the Computer Meteorological Message (METCM). The METCM is a commonly used form of meteorological information for artillery applications that is widely used[1]. The input included mean values and standard deviations of height, temperature, wind speed and direction, and various moisture variables such as relative humidity and dew point, plus other meteorological variables. The output had a form that contained the layer or zone mean values of the METCM, that is, wind speed, wind direction, virtual temperature, and pressure, plus zone mean values of other variables such as density. Also, the output variables had different units than normally found in a METCM. In addition, the output files contained tables where one or more standard deviations of one or more variables were added to or subtracted from the mean values so as to represent more extreme conditions.

2. Method

The software for the production of METCM type information from climatological mean and standard deviation (SD) data closely follows that developed earlier for generating METCMs and other meteorological messages from radiosonde data as well as from other sources such as numerical model based soundings. Cogan and Jameson[2] describe the main software routines, though certain ones have been modified since then. In particular, the code for ingest of input data was rewritten as was the code for producing the new forms of output. In addition algorithms were devised and coded to input and appropriately process SDs of the several variables. The program essentially treats the climate-based profiles as input to the routines for computing weighted mean values by zone (layer) in much the same way as input data from other sources. It also computes weighted mean values of the SDs by zone (layer) in a similar manner.

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[1] Department of the Army, FM 3-09.15 MCWP 3-16.5: Tactics, Techniques, and Procedures for Field Artillery Meteorology, 270 pp., 2007.

[2] Cogan, J.; Jameson, T. *Meteorological Message and Test Analysis Software for an Army Meteorological System;* ARL-TR-3249; U.S. Army Research Laboratory: Adelphi, MD, 2004.

The basic algorithms of the program are very briefly mentioned in this report with more detailed descriptions found in Cogan and Jameson[2]. The key routines include one to linearly interpolate the values at the boundaries of the METCM (or other message) zones and one to generate the integrated or weighted mean values for the layers or zones. The exception is the surface (zone 0) where the zone values are the surface values found in the input file or are computed from those input surface values. The interpolation equation is simply

$$X_n = X_{n-1} + (X_{n+1} - X_{n-1}) * (Z_n - Z_{n-1}) / (Z_{n+1} - Z_{n-1}) , \qquad (1)$$

where X is any variable (e.g., temperature), Z is height, and n–1, n, and n+1 indicate the value at the level immediately below, at, and immediately above the level of interest.

Figure 1 provides a sketch that illustrates the basic algorithm for computing the layer or zone weighted or integrated average values from a vertical profile of the meteorological variables where the zone boundary values have been computed. A mean value is computed for each sub-layer as defined by the data points and the zone boundaries. The layer mean is the weighted or integrated mean of the sub-layers. For the surface (zone 0), the "mean values" are the surface values. The program will generate appropriate output if at least two input data levels are available, one of which has to be the surface. Frequently, climatological and sounding heights are stated as above mean sea level (MSL), but the program will produce values for heights above ground level (AGL) using the site elevation. We set a maximum of 4000 levels that is more than adequate for climatological data or the real radiosonde soundings used as input in other versions of the program.

A user-selected number of SDs are added or subtracted to or from the mean values of one or more variables to produce new soundings that represent more extreme cases. For example, a fire control system would compute longer artillery ranges when the wind speed in the direction of fire increased by N * SD_w, where the subscript w denotes wind speed and where N represents some number greater than zero. A decrease in density could occur if temperature increased by N* SD_t (where the subscript t denotes temperature) and pressure remained the same, or if pressure decreased by N* SD_p (where the subscript p denotes pressure) with temperature the same. Since the input has the data levels based on standard pressure levels as well as the mean surface pressure, we converted SDs of height into SDs of pressure using the data provided. Also, the climate-based SD of density was provided in the input files, so that quantity was not computed. Since virtual temperature (T_v) is not listed in the climatological data files, we calculated it using the mean temperatures and mean relative humidities. The values of T_v as increased by some multiple of the SD were computed using the mean values of T_v and pressure, and the sum of the SD of relative humidity (RH) and the respective mean RH values. If the sum exceeded 100% the value was set at 100%. The output routine generates tables of measured variables (e.g., temperature) and computed quantities (e.g., virtual temperature). Section 3 provides some examples of the input and output files.

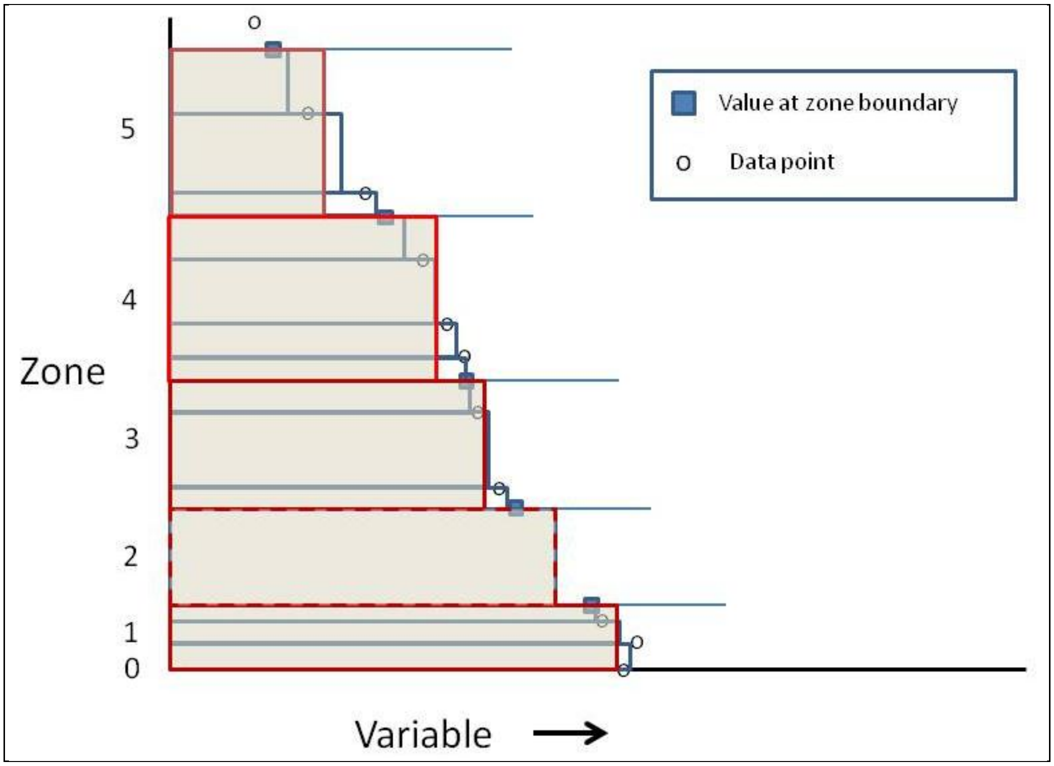

Figure 1. Illustration of the method to compute integrated or weighted mean zone values for a generic message (zone mean values indicated by red lines). The values at the zone boundaries were computed as noted in the text. Since Zone 2 contained no data, the mean is an average of the values at the zone boundaries and is the same as the sub-layer value (dashed red line overlying solid blue line designating the sub-layer).

The input file of climatological vertical profiles did not have the SD of pressure and it could not be computed from the SD of height at the surface since that is always 0. Consequently, we later obtained a file of climatological surface station data containing surface pressure means and SDs by month and season for each site. The relevant values were extracted and used to modify the SDs of pressure for zones 0 and 1. Modification of the zone 1 value was required since the mean SD of pressure for that zone included the lower boundary value, which is the original surface value of 0. The modified pressure SD for zone 1 was interpolated from the revised surface SD from the surface data file and the mean SD for zone 2. The surface station means and SDs are derived from data taken every hour versus every 12 h for the soundings used for the vertical profiles. Nevertheless, the mean pressures should be very close as suggested by the data as well as the SDs. The new interpolated SD for zone 1 (100 m midpoint) using the "new" surface value is closer to reality than the former one that included a surface SD of 0. Section 3 also includes a sample of output with the revised SDs of pressure. The appendix contains a brief guide for running the program as used for this report, both for the basic and modified forms.

3. Input and Output

The input files of vertical profiles of climatological means and SDs for the several variables and the files of surface pressure SDs were prepared by personnel of the 14th Weather Squadron (Zautner, private communication, 2013) of the U.S. Air Force in Ashville, NC. The input routines used in the program were modified to accept the various file formats that were produced. Most of the climatological files contained the same type of information, but here we present the latest and most common one used.

The input text files contain headers having information on the selected site, label the columns, and define the units of the mean and SD of the several variables. The method of obtaining the SDs assumes a standard distribution. Furthermore, all variables are treated independently, that is, any dependencies are ignored. The columns are arranged by variable and the rows by prescribed pressure level. Table 1 contains an example of the input data in tabular text form used for this work. The 14th Weather Squadron provided files for each month and season where winter, spring, summer, and autumn are represented, respectively, by climate data for Dec–Feb, Mar–May, Jun–Aug, and Sep–Nov.

Table 1. Sample of climatological input for the Lake Charles Municipal Airport, LA, radiosonde station for April based on data from 2003–2012. STD at the beginning of a variable name or abbreviation indicates the respective standard deviation.

KLCH LAKE CHARLES MUNI   Month Apr Mean Sounding Data Period: 2003 - 2012

PRES hPa	NOBS	HGHT m	STDH m	TEMP C	STDT C	RELH %	STDR %	DRCT deg	WSPD knot	STDW knot	UWND knot	STDU knot	VWND knot	STDV knot	DENS g/M3	STDD g/M3
1014.3	000578	000005	000000	0020.7	0005.0	0072.9	0021.6	000168	0008.4	0004.8	-000.7	0004.5	0003.2	0007.9	1202.63	023.26
1000.0	000592	000127	000040	0020.1	0004.0	0070.4	0022.0	000163	0013.4	0005.3	-001.5	0007.2	0005.0	0011.3	1188.15	016.62
0950.0	000596	000570	000045	0017.4	0003.6	0070.6	0023.5	000189	0017.6	0008.3	0001.1	0009.1	0007.2	0015.6	1139.24	014.53
0900.0	000585	001029	000041	0015.0	0003.8	0062.3	0026.6	000214	0017.8	0010.1	0004.0	0010.3	0006.0	0016.2	1088.13	014.54
0850.0	000591	001510	000035	0013.3	0003.7	0048.8	0030.8	000221	0019.3	0010.2	0006.0	0010.5	0006.9	0016.9	1034.01	013.49
0800.0	000596	002022	000045	0011.4	0003.4	0037.7	0030.4	000243	0020.0	0010.3	0009.7	0010.1	0005.0	0016.8	0979.64	011.80
0750.0	000597	002557	000045	0009.0	0003.3	0032.8	0029.3	000255	0020.5	0011.6	0011.9	0012.0	0003.1	0016.2	0926.12	010.76
0700.0	000596	003123	000038	0005.9	0003.2	0029.5	0027.3	000258	0021.9	0012.7	0014.6	0012.4	0003.0	0016.3	0873.88	010.02
0650.0	000595	003728	000056	0002.0	0002.9	0026.3	0024.7	000268	0023.1	0012.6	0016.8	0012.7	0000.6	0015.8	0822.95	008.66
0600.0	000595	004366	000045	-002.4	0002.6	0024.9	0024.6	000270	0025.8	0013.4	0019.9	0013.1	-000.1	0016.7	0771.98	007.42
0550.0	000595	005052	000049	-007.1	0002.3	0025.3	0025.5	000274	0029.0	0014.0	0023.8	0014.0	-001.6	0016.4	0720.34	006.34
0500.0	000591	005785	000051	-012.3	0002.2	0024.6	0026.5	000269	0032.9	0016.3	0028.0	0016.5	0000.3	0017.1	0667.79	005.69
0450.0	000594	006585	000068	-018.0	0002.2	0022.6	0025.0	000274	0035.6	0016.7	0029.7	0017.3	-002.0	0019.1	0614.36	005.38
0400.0	000593	007451	000061	-024.2	0002.2	0023.0	0025.3	000269	0039.9	0017.9	0035.6	0018.1	0000.4	0017.9	0559.85	005.04
0350.0	000594	008410	000069	-031.5	0002.2	0021.0	0021.8	000273	0044.6	0018.9	0039.0	0019.4	-002.4	0021.2	0504.52	004.64
0300.0	000592	009483	000073	-039.6	0002.3	0020.9	0019.7	000270	0052.4	0022.5	0047.5	0023.0	0000.1	0021.8	0447.59	004.34
0250.0	000590	010705	000079	-048.8	0002.4	0020.2	0016.7	000271	0061.4	0026.2	0055.8	0027.3	-001.2	0024.2	0388.28	004.09
0200.0	000590	012140	000082	-057.5	0003.4	0020.6	0014.6	000271	0069.5	0028.1	0064.0	0029.1	-001.0	0025.9	0323.23	005.01
0150.0	000589	013935	000076	-061.8	0003.4	0016.7	0011.0	000269	0063.1	0020.5	0059.8	0021.4	0001.2	0019.2	0247.27	003.97
0100.0	000587	016408	000065	-068.1	0002.9	0015.1	0009.4	000268	0042.9	0013.9	0040.1	0014.1	0001.6	0015.0	0169.89	002.39
0070.0	000584	018535	000050	-069.5	0003.4	0014.7	0009.3	000269	0021.5	0009.7	0017.8	0011.0	0000.4	0010.8	0119.75	002.01
0050.0	000582	020567	000044	-063.9	0002.7	0012.3	0009.2	000275	0010.6	0006.1	0004.1	0009.1	-000.4	0007.0	0083.26	001.08
0030.0	000568	023761	000060	-056.0	0002.4	0007.2	0007.5	000314	0010.1	0005.8	0001.4	0009.7	-001.4	0006.1	0048.12	000.53
0020.0	000557	026374	000080	-050.3	0002.8	0004.0	0005.9	000276	0012.9	0007.5	0005.4	0011.7	-000.6	0007.4	0031.27	000.39
0010.0	000447	030989	000112	-040.5	0003.2	0002.7	0003.9	000278	0024.2	0012.4	0017.1	0018.7	-002.3	0009.7	0014.97	000.21

Each output file contains the baseline message, which has the METCM zones, but is not in the usual METCM format. The units of the variables are different and additional variables are listed. The first column has the METCM zones followed by a column with the respective midpoint heights. The tables that follow the baseline consist of similar messages with one or more of the variables having a multiple of the relevant SD added or subtracted to or from the baseline values. The SDs for the several variables are listed in a table at the end of the file. Table 2 shows a sample of the baseline “message” from one output file for the same location and month (April) as the sample input.

Table 2. Sample baseline “message” output from one file is shown. The header contains information on the location and month plus the variables and units.

Line	**Height (m)**	**Pressure (Pa)**	**Wind Direction (degrees)**	**Wind Speed (m/s)**	**Temperature (C)**	**Virtual Temp (C)**	**Density (kg/M3)**
BASELINE (climatological) meteorological message							
0	0	101430.00	168.0	4.3	20.7	22.7	1.2026
1	100	100263.84	165.3	6.2	20.2	22.1	1.1909
2	350	97387.73	178.2	8.0	18.7	20.5	1.1630
3	750	92938.57	199.2	9.1	16.4	17.9	1.1186
4	1250	87638.05	217.4	9.5	14.2	15.3	1.0627
5	1750	82569.12	231.7	10.1	12.4	13.2	1.0080
6	2250	77755.74	248.3	10.4	10.4	11.0	0.9563
7	2750	73233.73	256.1	10.8	7.9	8.4	0.9079
8	3250	68889.39	260.4	11.4	5.0	5.4	0.8629
9	3750	64755.93	267.5	12.0	1.8	2.1	0.8210
10	4250	60859.11	269.8	13.0	–1.6	–1.4	0.7809
11	4750	57113.43	272.4	14.2	–5.1	–4.9	0.7427
12	5500	51860.29	271.1	16.1	–10.3	–10.2	0.6880
13	6500	45458.16	272.5	18.2	–17.4	–17.4	0.6200
14	7500	39719.57	270.2	20.7	–24.7	–24.6	0.5573
15	8500	34530.32	272.1	23.4	–32.2	–32.2	0.4999
16	9500	29898.27	270.4	27.0	–39.8	–39.8	0.4470
17	10500	25768.60	270.8	30.8	–47.2	–47.2	0.3981
18	11500	22102.36	271.0	33.9	–53.7	–53.6	0.3520
19	12500	18879.59	270.6	35.0	–58.3	–58.3	0.3078
20	13500	16083.11	269.5	33.2	–60.8	–60.8	0.2655
21	14500	13674.99	268.8	30.1	–63.3	–63.3	0.2294
22	15500	11608.82	268.5	25.9	–65.8	–65.8	0.1981
23	16500	9835.69	268.1	21.5	–68.0	–68.0	0.1682
24	17500	8326.45	268.3	16.4	–68.8	–68.8	0.1440
25	18500	7042.74	269.0	11.5	–69.1	–69.1	0.1211
26	19500	5954.81	270.9	8.4	–66.8	–66.8	0.1023
27	21000	4656.03	280.1	5.6	–62.8	–62.8	0.0790
28	23000	3376.76	304.3	5.3	–57.9	–57.9	0.0565
29	25000	2469.61	293.5	5.9	–53.3	–53.3	0.0401
30	27000	1815.31	276.8	7.5	–49.0	–48.9	0.0291

Tables 3–6 present changes that would increase artillery range, for example, higher temperature, lower pressure, lower density (a result of higher temperature and/or lower pressure), and higher wind speed. For brevity the remaining tables show only the first 15 lines. The variables and units are the same as in the baseline message. In each table, one variable is increased by the respective SD except one table has the appropriate increases in both temperature and virtual temperature. The other variables retain their mean values. Table 3 presents the message with one SD of wind speed added to the baseline values as requested by the user. Table 4 has one SD of density subtracted; table 5 presents one SD of temperature added to temperature and the related increase in virtual temperature; and table 6 shows one SD of pressure subtracted from the respective mean pressure values.

Table 3. Sample "message" output for zones 0–15 where one standard deviation of wind speed was added to the mean values. The variables and units are the same as in table 2.

Wind speed standard deviation x 1.000 added.

0	0	101430.0	168.0	6.8	20.7	22.7	1.2026
1	100	100263.8	165.3	8.9	20.2	22.1	1.1909
2	350	97387.7	178.2	11.5	18.7	20.5	1.1630
3	750	92938.6	199.2	13.7	16.4	17.9	1.1186
4	1250	87638.1	217.4	14.7	14.2	15.3	1.0627
5	1750	82569.1	231.7	15.4	12.4	13.2	1.0080
6	2250	77755.7	248.3	16.0	10.4	11.0	0.9563
7	2750	73233.7	256.1	17.0	7.9	8.4	0.9079
8	3250	68889.4	260.4	17.9	5.0	5.4	0.8629
9	3750	64755.9	267.5	18.5	1.8	2.1	0.8210
10	4250	60859.1	269.8	19.9	–1.6	–1.4	0.7809
11	4750	57113.4	272.4	21.3	–5.1	–4.9	0.7427
12	5500	51860.3	271.1	24.0	–10.3	–10.2	0.6880
13	6500	45458.2	272.5	26.9	–17.4	–17.4	0.6200
14	7500	39719.6	270.2	29.9	–24.7	–24.6	0.5573
15	8500	34530.3	272.1	33.4	–32.2	–32.2	0.4999

Table 4. Sample "message" output for zones 0–15 where one standard deviation of density was subtracted from the mean values. The variables and units are the same as in table 2.

Density standard deviations x 1.000 subtracted.

0	0	101430.0	168.0	4.3	20.7	22.7	1.1794
1	100	100263.8	165.3	6.2	20.2	22.1	1.1723
2	350	97387.7	178.2	8.0	18.7	20.5	1.1474
3	750	92938.6	199.2	9.1	16.4	17.9	1.1041
4	1250	87638.1	217.4	9.5	14.2	15.3	1.0487
5	1750	82569.1	231.7	10.1	12.4	13.2	0.9953
6	2250	77755.7	248.3	10.4	10.4	11.0	0.9450
7	2750	73233.7	256.1	10.8	7.9	8.4	0.8974
8	3250	68889.4	260.4	11.4	5.0	5.4	0.8532
9	3750	64755.9	267.5	12.0	1.8	2.1	0.8124
10	4250	60859.1	269.8	13.0	–1.6	–1.4	0.7733
11	4750	57113.4	272.4	14.2	–5.1	–4.9	0.7359
12	5500	51860.3	271.1	16.1	–10.3	–10.2	0.6820
13	6500	45458.2	272.5	18.2	–17.4	–17.4	0.6146
14	7500	39719.6	270.2	20.7	–24.7	–24.6	0.5522
15	8500	34530.3	272.1	23.4	–32.2	–32.2	0.4952

Table 5. Sample "message" output for zones 0–15 where one standard deviation of temperature and virtual temperature (see text) was added to the mean values of temperature and virtual temperature. The variables and units are the same as in table 2.

Temperature standard deviation x1.000 added.

0	0	101430.0	168.0	4.3	25.7	29.2	1.2026
1	100	100263.8	165.3	6.2	24.5	27.7	1.1909
2	350	97387.7	178.2	8.0	22.5	25.5	1.1630
3	750	92938.6	199.2	9.1	20.1	22.7	1.1186
4	1250	87638.1	217.4	9.5	18.0	20.2	1.0627
5	1750	82569.1	231.7	10.1	15.9	17.7	1.0080
6	2250	77755.7	248.3	10.4	13.7	15.2	0.9563
7	2750	73233.7	256.1	10.8	11.2	12.4	0.9079
8	3250	68889.4	260.4	11.4	8.2	9.1	0.8629
9	3750	64755.9	267.5	12.0	4.7	5.4	0.8210
10	4250	60859.1	269.8	13.0	1.0	1.6	0.7809
11	4750	57113.4	272.4	14.2	–2.6	–2.2	0.7427
12	5500	51860.3	271.1	16.1	–8.1	–7.7	0.6880
13	6500	45458.2	272.5	18.2	–15.2	–15.0	0.6200
14	7500	39719.6	270.2	20.7	–22.5	–22.3	0.5573
15	8500	34530.3	272.1	23.4	–30.0	–29.9	0.4999

Table 6. Sample "message" output for zones 0–15 where one standard deviation of pressure was subtracted from the mean values. The variables and units are the same as in table 2. Since this table was computed using the basic version of the program the SD of pressure for the surface (zone 0) was 0 and the value for zone 1 was too small as noted in the text.

Pressure standard deviation x 1.000 subtracted.

0	0	101430.0	168.0	4.3	20.7	22.7	1.2026
1	100	99942.4	165.3	6.2	20.2	22.1	1.1909
2	350	96909.7	178.2	8.0	18.7	20.5	1.1630
3	750	92470.8	199.2	9.1	16.4	17.9	1.1186
4	1250	87246.2	217.4	9.5	14.2	15.3	1.0627
5	1750	82181.7	231.7	10.1	12.4	13.2	1.0080
6	2250	77340.1	248.3	10.4	10.4	11.0	0.9563
7	2750	72860.5	256.1	10.8	7.9	8.4	0.9079
8	3250	68534.5	260.4	11.4	5.0	5.4	0.8629
9	3750	64333.6	267.5	12.0	1.8	2.1	0.8210
10	4250	60500.9	269.8	13.0	–1.6	–1.4	0.7809
11	4750	56773.4	272.4	14.2	–5.1	–4.9	0.7427
12	5500	51522.6	271.1	16.1	–10.3	–10.2	0.6880
13	6500	45076.0	272.5	18.2	–17.4	–17.4	0.6200
14	7500	39379.5	270.2	20.7	–24.7	–24.6	0.5573
15	8500	34197.2	272.1	23.4	–32.2	–32.2	0.4999

The last listing (table 7) in each output file contains the input SD for each of the variables for each zone or layer and the surface. SD of pressure is not in the input files, but is computed using the SD of height. The surface height (elevation) does not change, meaning that the SD of height is 0 and consequently the computed SD of pressure is 0. The value for zone 1 uses the value for the surface in the computation of the mean value and therefore is too low.

Table 7. Standard deviations for zones 0–15 used in the generation of the output "message" files. WS = wind speed, Temp = temperature, Dens = density, Hum = relative humidity, and P = pressure. The zone midpoint heights are listed, but not the zone numbers. SD P computed using the SD of height.

Standard deviation of input variables from input file

Height (m)	**SD Height (m)**	**SD WS (m/s)**	**SD Temp (K)**	**SD Dens (kg/M3)**	**SD Hum (Percent)**	**SD P (Pa)**
0	0.0	2.5	5.0	0.0233	21.6	0.0
100	28.0	2.7	4.3	0.0186	21.9	321.5
350	42.6	3.5	3.8	0.0155	22.8	478.0
750	43.3	4.6	3.7	0.0146	24.8	467.7
1250	38.2	5.2	3.8	0.0140	28.6	391.9
1750	39.8	5.3	3.6	0.0127	30.6	387.4
2250	45.0	5.6	3.4	0.0113	29.9	415.6
2750	42.5	6.2	3.3	0.0105	28.6	373.3
3250	42.5	6.5	3.1	0.0097	26.7	354.9
3750	53.2	6.5	2.9	0.0086	24.9	422.3
4250	47.4	6.8	2.7	0.0076	24.6	358.2
4750	47.3	7.1	2.4	0.0068	25.1	340.0
5500	50.7	7.9	2.2	0.0060	26.0	337.7
6500	63.7	8.6	2.2	0.0054	25.3	382.1
7500	63.1	9.2	2.2	0.0050	24.7	340.1
8500	69.0	10.0	2.2	0.0046	21.8	333.1

In the revised version of the program, we extracted the SD of the surface pressure from files of climatological surface data supplied by the 14th Weather Squadron and used the relevant value for the surface and an interpolated SD for zone 1 using the surface value and the value computed as before for zone 2. Table 8 presents output for Norman, OK, for 2*SD of pressure. Table 9 has the SDs of the several variables as in table 7, but the pressure values for zone 0 (surface) and 1 are modified as noted above and in section 2.

Table 8. Sample "message" output for zones 0–15 for Norman, OK, where two standard deviations of pressure were subtracted from the mean values. The variables and units are the same as in table 2.

Pressure standard deviation x 2.000 subtracted.

0	0	96610.0	133.0	3.3	23.2	25.3	1.1454
1	100	95510.4	150.7	5.1	23.1	25.1	1.1336
2	350	92811.9	167.5	7.6	22.2	24.1	1.1058
3	750	88756.1	186.5	8.4	19.8	21.5	1.0643
4	1250	83752.6	209.7	8.3	16.9	18.4	1.0141
5	1750	78971.6	233.8	8.0	14.2	15.5	0.9651
6	2250	74409.1	256.0	8.1	11.5	12.5	0.9181
7	2750	70050.6	270.2	8.3	8.6	9.4	0.8733
8	3250	65889.0	273.0	8.5	5.6	6.2	0.8308
9	3750	61943.5	276.0	8.7	2.5	3.0	0.7900
10	4250	58179.0	278.4	9.0	–0.5	–0.1	0.7506
11	4750	54612.6	277.2	9.3	–3.4	–3.1	0.7124
12	5500	49578.0	276.5	10.0	–7.9	–7.7	0.6586
13	6500	43406.7	273.9	11.3	–14.6	–14.5	0.5932
14	7500	37904.5	272.3	13.2	–21.7	–21.6	0.5335
15	8500	32903.8	271.0	15.1	–29.1	–29.1	0.4791

Table 9. Standard deviations for zones 0–15 used in the generation of the output "message" files for Norman, OK. WS = wind speed, Temp = temperature, Dens = density, Hum = relative humidity, and P = pressure. The zone midpoint heights are listed, but not the zone numbers. The pressure value for height 0 was taken from the respective surface data file and re-computed for the layer immediately above (midpoint of 100 m). SD P computed using the SD of height for zones 2 and above. See text for zones 0 and 1.

Standard deviation of input variables from input file

Height (m)	**SD Height (m)**	**SD WS (m/s)**	**SD Temp (K)**	**SD Dens (kg/M3)**	**SD Hum (Percent)**	**SD P (Pa)**
0	0.0	2.0	5.9	0.0252	23.4	400.0
100	16.5	2.8	5.3	0.0219	22.3	395.1
350	37.2	4.2	4.4	0.0167	20.6	382.8
750	35.8	4.8	3.8	0.0139	20.8	357.1
1250	34.0	4.8	3.2	0.0113	23.9	324.9
1750	33.1	4.6	2.9	0.0098	26.0	302.3
2250	33.1	4.5	2.7	0.0088	26.4	288.6
2750	33.9	4.6	2.5	0.0079	26.7	281.5
3250	34.7	4.8	2.4	0.0073	26.9	274.8
3750	36.0	5.0	2.4	0.0069	27.7	271.2
4250	37.5	5.3	2.4	0.0066	28.6	268.6
4750	39.0	5.5	2.4	0.0064	28.7	265.3
5500	42.5	5.9	2.4	0.0061	26.8	267.1
6500	49.6	6.5	2.6	0.0061	22.9	280.0
7500	56.4	7.3	2.9	0.0061	21.6	285.9
8500	66.5	8.2	3.1	0.0060	21.7	301.4

4. Conclusion

The computation of METCM information from climatological vertical profile data that include SDs of the several variables will allow the user to generate appropriate scenarios for simulated firing solutions. These solutions may be used to help assess safety zones on national ranges for artillery and related applications. In this report, we generated messages with changes of one or two SDs of the relevant variables. More extreme conditions may be simulated using a larger multiple of the SDs. For example, a multiplier (N) of 3.09 would provide about a 0.1% chance of wind speed exceeding a value equal to the mean plus N * wind speed SD. The program is designed to handle multipliers of $0 < N < 10$, so any feasible extreme may be computed.

Appendix. Short Guide to Generating METCM Output from Climatological Sounding Data

This appendix presents a very short guide to running the two versions of the program for generation of METCM type output from climatological sounding data, putting them in a tabular format, and producing messages with SDs added or subtracted to wind speed, density, temperature (and/or) virtual temperature, and pressure.

This brief guide only lists the steps to run the programs for the purpose noted above, and only for the version that does not use a parameter file for the SD multiplier (defined below) and uses 14th Weather Squadron climate files. It has SDs of height (vs. SD of pressure) as well as for the other variables, including SDs of wind speed, relative humidity, u, v components of the wind, and density.

There are two versions. Steps for generation of output files for the latest version follow:

1. Check input_parameters for correct paths for input and output.
2. Check for the correct input file (e.g., excal_KLCH_723570_Sep) and file of surface pressure data (e.g., KLCH_surface).
3. Type and return the command line **./convertexcalmost3 "input file name" "multiplier value" "surface pressure file"** (e.g., ./convertexcalmost3 SiteX_NOV_north 3.5 SiteX_surface), where the input file has the means and SDs, the multiplier value is the number of SDs used for the calculation of "extreme" MET messages, and the surface file has the SD of pressure at the surface.

For the basic version, follow the same steps except the file for SD of surface pressure is not used:

1. Check input_parameters for correct paths for input and output.
2. Check for the correct input file (e.g., excal_KLCH_723570_Sep).
3. Type and return the command line **./convertexcalmost2 "input file name" "multiplier value"** (e.g., ./convertexcalmost2 SiteX_NOV_north 3.5), where the input file has the means and SDs, and the multiplier value is the number of SDs used for the calculation of "extreme" MET messages..

Notes:

a. The climate data files from the 14th Weather Squadron contain both mean values and SDs.

b. The main output file contains the baseline message, messages with + or – a multiple of the SDs added or subtracted to the means for one or more of the variables, and the SDs used as input. A second output file contains the baseline message with additional header information.

c. Both “convertexcalmost2” and “convertexcalmost3” read in the mean and SD values and convert the climatological sounding into a message with a METCM type format, and produce messages with the SDs added/subtracted to/from the message values for the appropriate variables. Compile using **./ccmsg_excalmost2** or **./ccmsg_excalmost3**, respectively.

d. The main output file has _CLIMO_xSD added to the input file name, where x is a number $0 < x < 10$.

e. The basic version has a surface (zone 0) pressure SD of 0 since the SD of height is 0 at the surface. The value for zone 1 is too low since the computation of the value for that zone includes the surface value. The latest version obtains the surface (zone 0) value from a separate file that contains the SD of surface pressure by month and season. The value for zone 1 is computed using the revised surface value and the pressure SD for zone 2.

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